Nematology Circular No. 144
August 1987

Fla. Dept. Agric. & Consumer Serv.
Division of Plant Industry

BIOLOGICAL CONTROL OF NEMATODES BY NEMATODES. I. DORYLAIMS (NEMATODA: DORYLAIMINA)

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Two or more genera of dorylaims are found in most soil samples examined for nematodes, making them one of the most ubiquous groups of nematodes occurring in Florida soils. Their abundance has been estimated at 200-500 million/acre (9).

Characterization: Dorylaims are usually large, almost always larger than their prey (Fig. 1-B), soil and water dwelling nematodes, many species of which are predaceous on other nematodes, small invertebrates and ova. Most dorylaims possess an unusually large well defined hollow spear (onchiostyle) (Fig. 1-E) used to pierce the body of prey, and other food sources. The hollow spear also serves in a soda straw capacity to inject enzymes into the food source, and to suck out the predigested contents. Most dorylaims possess an elongate, cylindrical, muscular esophagus (Fig. 1-D) with internal esophageal gland openings serving as an enzyme pump.

Prey: Dorylaims attack, pierce, and feed on many genera and species of nematodes, oligochaetes, rotifers (Fig. 1-C), and other minute invertebrates in addition to a wide variety of invertebrate eggs. Known predaceous dorylaims and their prey include: Actinolaimus sp. on Meloidogyne sp. (6); Aporcelaimus sp. on bacteriophagous nematodes (Fig. 1-B); Carcharolaimus sp. on Rotylenchulus reniformis Linford & Oliviera 1940 (Fig. 1-A); Discolaimus sp. on Aphelenchus sp. and Meloidogyne sp. (5); Dorylaimus sp. on Meloidogyne sp. (5); Eudorylaimus sp. on algae, fungi, and Bursaphelenchus xylophylus and Eudorylaimus obtusicaudatus (Bastian, 1865) Andrassy, 1959 on Heterodera schachtii Schmidt 1871 (Fig. 1-E); Labronema vulvapapillatum Meyl 1954 on Globodera rostochiensis (Wollenweber, 1923) Behrens, 1975; Meloidogyne naasi Franklin, 1965, and Panagrellus redivivus (Linn., 1767) Goodey, 1945 (7); Neoactinolaimus duplicidentatus (Andrassy, 1968) Andrassy, 1970 on Panagrellus redivivus (7); Thornia sp. on amoeba, Aphelenchus avenae, and Tylenchulus semipenetrans Cobb, 1913; dorylaims (unnamed genera) have also fed on Criconemoides sp. (Fig. 1-G), Meloidodera floridensis, Chitwood, Hannon and Esser, 1956, Paratylenchus curvatatus van der Linde, 1958, Pratylenchus penetrans (Cobb, 1917) Filipjev and Schuurmans Stekhoven, 1941, and P. vulnus Allen and Jensen, 1951.

Locating Prey: In the maze-like endless network of tunnels formed by the conjunction of irregularly shaped soil particles, numerous chance meetings must occur between predator and prey. In this constricted habitat with many blind alleys, it could prove quite difficult for cornered prey to escape the sure thrust of the hollow spear. On agar when a large nematode was severed with a scalpel, several dorylaims converged on the site rather quickly, from varying distances, to feed on the wounded nematode with its life fluids oozing out. This indicated a chemical attraction to the feeding site. It is not uncommon to see two or more dorylaims feeding on a single prey.

Attack: When the lips of a dorylaim contact its prey, the lips move over the surface in a very brief pre-penetration exploration. A large female in culture

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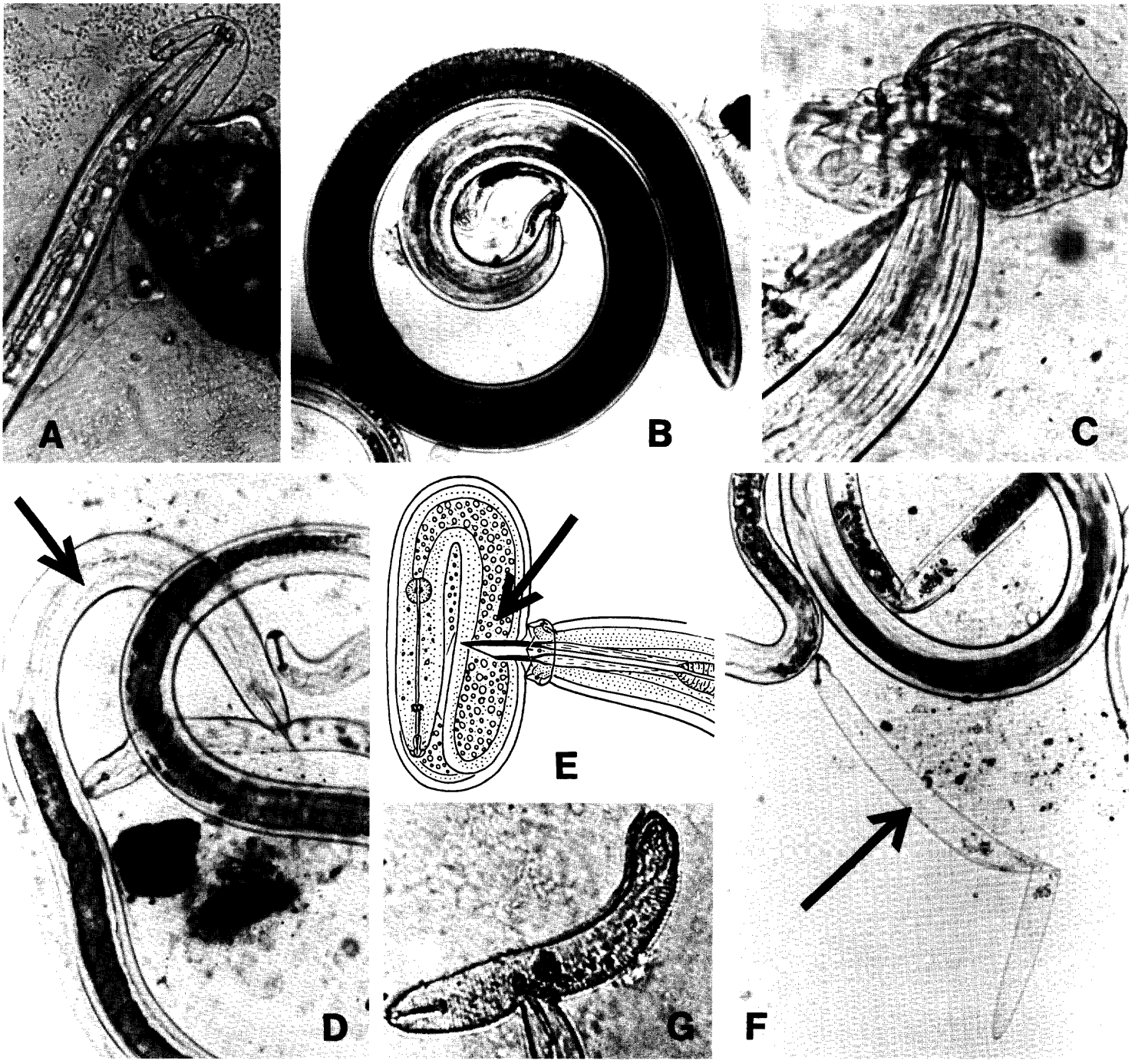

Fig. 1. Attacking dorylaims: A. Carcharolaimus sp. feeding on reniform nematode (Rotylenchulus reniformis); B. Aporcelaimus sp. feeding on a bacteriophagous nematode; C. Dorylaim attacking rotifer; D. Dorylaim feeding on Pratylenchus sp. (arrow: muscular cylindrical esophagus); E. Eudorylaimus obtusicaudatus feeding on egg of Heterodera schachtii after Thorne (arrow at onchiostyle); F. Empty body shell (arrow) of Pratylenchus sp. sucked empty by dorylaim. G. Dorylaim feeding on Criconemoides sp. (note accumulation of oil globules at hollow spear tip).

deposited 30-40 eggs; then explored one of her own eggs for 20 minutes without piercing it. A male of the same species also lip explored the egg but did not attempt to pierce it (3). Dorylaims thrust their hollow spears against the prey epidermis or egg shell until penetration is effected (Fig. 1-D)

Feeding: Once the hollow spear is inside the epidermis, the elongate muscular esophagus begins to contract rhythmically. Enzymes enter the prey body from the hollow spear tip and push back the internal fat globules inside the prey in the area of the spear tip. Enzyme action reduces the globules until they are small enough to enter the hollow spear, at which time esophageal contractions cease and fluids from the prey enter the spear tip. At this time, the globules flow to and cluster about the spear tip (Fig. 1-G) until all the small ones have entered. This is followed by more contractions, more enzymes, more intake until the prey body is a hollow shell (Fig. 1-F).

Resistance: Some phytoparasitic nematodes are rarely or unsuccessfully attacked by dorylaims (4). In agar cultures, resistance was shown by Hoplolaimus tylenchiformis Daday, 1905, Belonolaimus longicaudatus Rau, 1958, Hemicycliophora similis Thorne, 1955, Dolichodorus heterocephalus, Cobb, 1914, Criconemoides spp., Scutellonema spp., and Helicotylenchus spp. Resistance may be chemical or physical. Chemical resistance was indicated in two cases of a violent withdrawal of a dorylaim that made lip contact with a female Helicotylenchus. After spear withdrawal, the dorylaim simulated regurgitation. Many thousands of Helicotylenchus spp. have been seen in close association with dorylaims without any attack. Physical resistance is evident when dorylaims fail to penetrate the thick epidermis of a nematode such as Hoplolaimus spp. despite repeated onchiostyle thrusts. A wounded, ordinarily resistant, thick skinned sting nematode was fed on by several dorylaims. Resistance may be lost by wounded nematodes or nematodes in a weakened condition (Fig. 1-G).

Biological Control Potential: The widespread occurrence of predaceous dorylaims in Florida soils indicates continuous biological control activity by the predators. What we do not know is to what degree populations of phytoparasitic nematodes are reduced by Dorylaims. Thorne's detection of Eudorylaimus obtusicaudatus in Heterodera schachtii cysts feeding on eggs (8) indicates more than a casual role. In pot tests with Thornia sp. and citrus nematodes, the predators increased in the presence of citrus nematode, and decreased in the absence of citrus nematode; however, no growth response was observed in pots where the populations of citrus nematodes were reduced by Thornia sp. (1). One hour after adding 500 specimens of Paratylenchus curvitatus to a culture containing mixed dorylaim genera many were succumbing to attack. In 3 days there were only a few survivors. Two days after adding 1000 Pratylenchus penetrans to a culture containing several genera of dorylaims all had been devoured, 176 more were added in the afternoon, none of which were alive the next morning.

Conclusions: Predaceous dorylaims are continuously cornering and piercing invertebrate prey including many kinds of phytoparasites with hollow spears in the endless stygian tunnels created by soil structure. They must be considered a viable factor in the biological control of phytoparasites, particularly larvae migrating in soil emanating from females whose bodies are partially or totally inside roots such as citrus, cyst, root-knot and lesion nematodes. Since they are omnivorous, feeding on algae, fungi, and invertebrates, it is conceivable that one day they will be reared on algal or fungal cultures for utilization in biological control. Christie (2) concluded: the possibility of using predaceous nematodes in the biological control of plant parasites is an attractive and unexplored field awaiting investigation.

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Contribution No. 329, Bureau of Nematology

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